Multispecies perspectives on the Bering Sea ground fishery management regime

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Introduction

The structure of the Bering Sea, dominated by pollock, is the result of several changes that have occurred in the last decades. Some species of flatfish, forage fish, crustaceans, marine mammals and seabirds have declined while some finfish species populations grew rapidly. A combination of environmental changes and human exploitation is the most likely explanation of the changes in the Bering Sea. Although groundfish exploitation rates in the last 20 years have been relatively low, concerns have been expressed about possible implications of uneven harvesting rates on groundfish in the eastern Bering Sea. Some groundfish, such as pollock, and cod, are harvested at or close to their allowable biological catch (ABC) while other are harvested at substantially lower levels. In order to address this concern, we have used results from MSVPA applied to a eight species system (Figure 1) to forecast the long-term effects of two harvesting regimes F_{ref} and F_{ABC} and a scenario of no fishing.

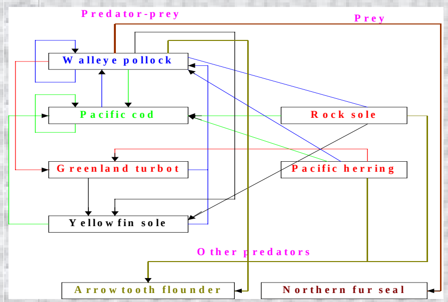

Figure 1. Biomass flow of the system defined for the eastern Bering Sea

Methods

The "reference F" level used was the average of the *F* estimates from MSVPA from the last four years (1995-1998). The level of fishing mortality producing the *Acceptable Biological Catch* (F_{ABC}) was estimated using the F_{ABC} values and the selectivity patterns for each species reported in 1998 stock assessment, with the exception of herring. For Pacific herring, 20% of the exploitable biomass has historically been used as the management criterion (Figure 2). A total of six multispecies and single species runs were used in the analysis. Three indicators, yield, total biomass and spawning biomass, were chosen from the single species (SSFOR) and the multispecies (MSFOR) forecasting. We compared the relative performance of these indicators in the F_{ABC} and $F = 0$ levels relative to the reference case using the following equation:

$$\%\ change\ of\ I = \frac{(I(F_{ABC}) - I(F_{ref}))}{I(F_{ref})} x100$$

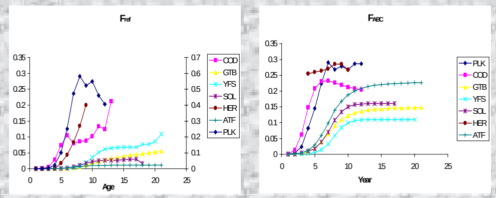

Figure 2. Fishing mortalities used in the forecasting, Fref on the left and FABC on the right. PLK- walleye pollock, COD- Pacific cod, GTB – Greenland turbot, YFS – yellowfin sole, SOL – rock sole, HER – Pacific herring, ATF – Arrowtooth flounder.

Results

F_{ABC} level is smaller than F_{ref} for walleye pollock. For the rest of the species, F_{ABC} is larger than F_{ref}, except for herring (constant 20% harvest rate). This pattern of *F* affected directly the general trend in the long-term relative changes of yield. Single and multispecies results followed almost the same trend. Walleye pollock and herring exhibited a decreased yield compared to yield obtained under the F_{ref} regime. The opposite tendency was found for the rest of the species, which showed increases in the long-term yield (Figure 3). Some predictions of SSFOR and MSFOR are different in relative magnitude of yields. These differences are due to changes of prey consumption caused indirectly by the increase of F on the predator. Single species models can not predict this effect.

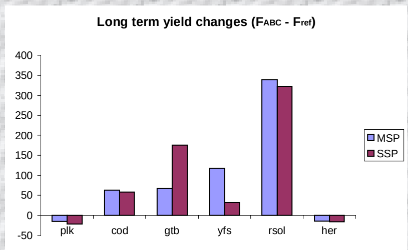

Figure 3. Long term changes of yield relative to Fref predicted by MSFOR and SSFOR. MSP-multispecies forecasting, SSP single species forecasting.

MSFOR and SSFOR predicted almost the same long-term change of total and spawning biomass for the F_{ABC} cases relative to the reference case. The largest difference between the two forecasts of total and spawning biomass corresponded to rock sole and herring. These differences are due to predation interactions. One of their main predators is cod. When cod is subjected to a higher *F*, cod's population is reduced diminishing the consumption of rock sole and herring and allowing the growth of their biomass. Pacific herring is an extreme case because the tendencies for changes of biomass predicted are opposites in sign (Figure 4). The difference between MSFOR and SSFOR predictions for total and spawning biomass for the rest of the species were less than 5%. In particular, changes predicted for pollock are similar (17.4% for MSFOR and 21.4% for SSFOR). A reduction of *F* produces a higher survival of pollock adults increasing the cannibalism of pollock juveniles. Simultaneously, the increase of *F* on other pollock predators produced a reduction of the consumption of pollock such that both predation effects almost compensate each other producing only a slight change in predation mortality. In summary, SSFOR and MSFOR predicted that the implementation of F_{ABC} would result in small alterations in the structure of the system.

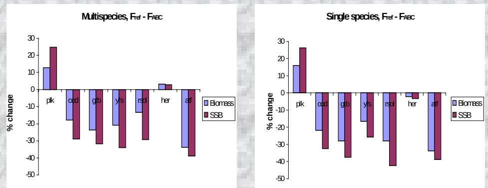

Figure 4. Relative percentage change of total and spawning biomass under two levels of fishing mortality. Left side compares the F_{ref} and F_{ABC} under a multispecies scenario . Right side compares both levels of fishing mortality under the single species scenario. Biomass-total biomass, SSB-spawning biomass.

A stronger discrepancy between the SSFOR and MSFOR results was found with a no fishing scenario. SSFOR predictions of total and spawning biomass of all species were higher than MSFOR's predictions. For example, the increase of spawning biomass of pollock predicted by SSFOR is almost 100% in the absence of fishing (Figure 5). The increase predicted by MSFOR is more modest (31 %) because the null fishing mortality allows the increase of pollock's predators populations (including pollock itself) resulting in an increase of predation mortality and consumption of pollock, reducing the growth of the pollock population. Similar cases were found for the rest of the species with an extreme case for rock sole. In absence of fishing, cod population grows in such way that its consumption of rock sole produces a decline of rock sole population not predicted by single species forecast. Multispecies results suggest that the implementation of a policy of no fishing causes the increase of predator populations slowing down the growth of prey species. Therefore the increment of some populations is smaller than the single species predictions leading to potential overestimation of populations. This analysis could be useful in the design of plans of recovery for depleted populations because predation interactions could potentially change the time of recovery of the target population.

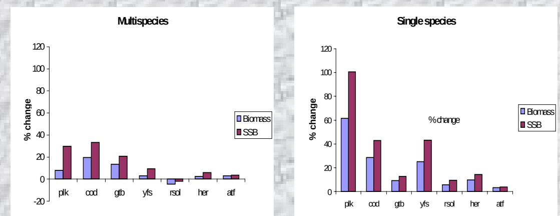

Figure 5. Relative percentage change of total and spawning biomass under two levels of fishing mortality. Left side compares the F_{ref} and no fishing levels under the multispecies scenario. The right side corresponds to the single species scenario (Biomass-total biomass, SSB-spawning biomass).

Conclusions

- SSFOR and MSFOR suggest that the implementation of the FABC would produce small long-term changes in the structure of the eastern Bering Sea groundfish populations compared to FREF.
- Changes in F can indirectly affect the predation mortality of prey due to changes in predator population.
- The implementation of the FABC regime resulted in no significant change in pollock predation mortality due to canceling effects of pollock consumption by arrowtooth flounder and adult pollock (cannibalism).
- When FABC was implemented, SSFOR and MSFOR predicted almost the same trends for the indicators analyzed. However, some differences for rock sole and Pacific herring due to predation interactions were observed.
- Multispecies simulations of no fishing scenarios changes our perspective on recovery times for depleted populations.